Characterizing Sediment-Water Nutrient Interaction Following an In-Lake Alum Treatment in a Shallow, Polymictic Reservoir

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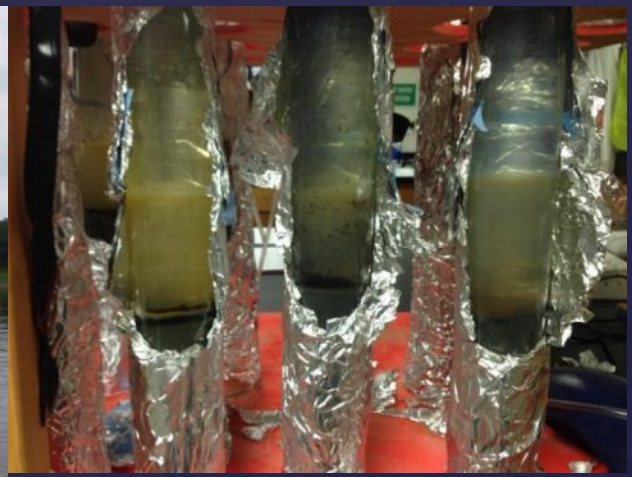

OCLWA, Stillwater, OK
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bioXdesign

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- Choctaw Nation
- City of Poteau
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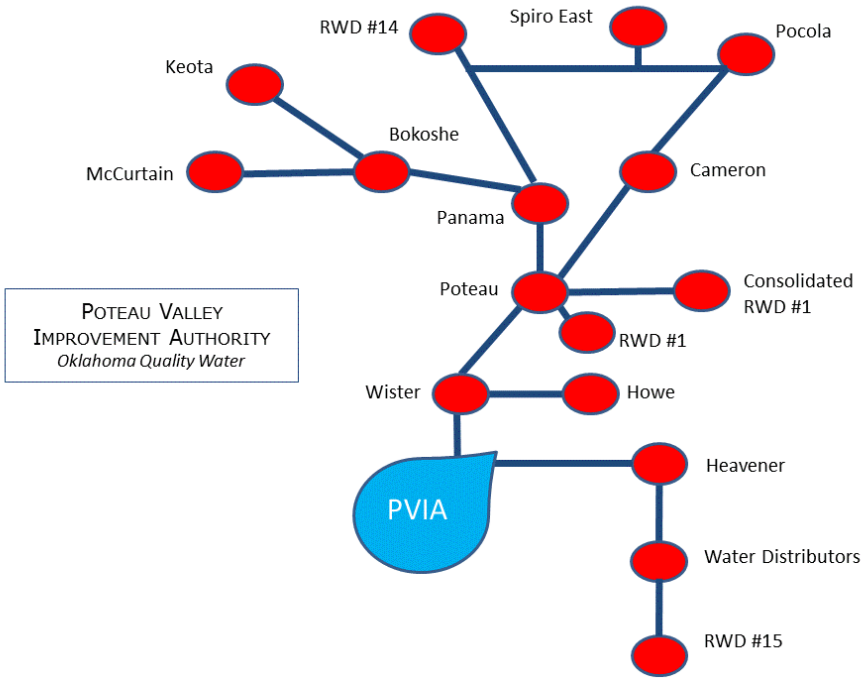
Erin Grantz & Brina Smith, Univ. of Arkansas



Ken Hammond, center, chairman of Poteau Valley Improvement Authority, helps area students prepare floating rafts Wednesday at Wister Lake. The rafts are designed to absorb harmful nutrients and phosphates from the water. The event was hosted by Choctaw Nation of Oklahoma and Poteau Valley Improvement Authority in an effort to clean up Lake Wister.

PHOTOS BY KAIA LARSEN • TIMES RECORD

Dedicated to Dr. Ken Hammond

(1948-2016)

Longtime Chairman of the PVIA Board of Trustees

Internal loading

- Results from accumulation of nutrients in lake sediments

Internal loading

- Once in the lake, limited options for reducing P , tend to accumulate & cycle:
    - P comes in from watershed & P released from sediments
    - Fertilizes algae & cyanobacteria
    - Algae die, sink to the bottom
    - Decomposed, releases P back to the water, some of that readsorbed by sediments
    - …

Internal loading

- Characterizing & quantifying can be complex
  - P movement from sediment particles to water & back

Internal loading

- Measures
    - Diffusive phosphorus flux
    - Equilibrium phosphorus concentration (EPC0)
    - Sequential fractionaction--quantify potentially mobile P in sediments

Internal loading

- P fractions

P-fraction	Extractant
Labile	DI H2O
Fe-P	Sodium bicarbonate (NaHCO3)
Al-P	Sodium hydroxide (NaOH)
Ca-P	Hydrochloric acid (HCl)
Totals	

Internal loading

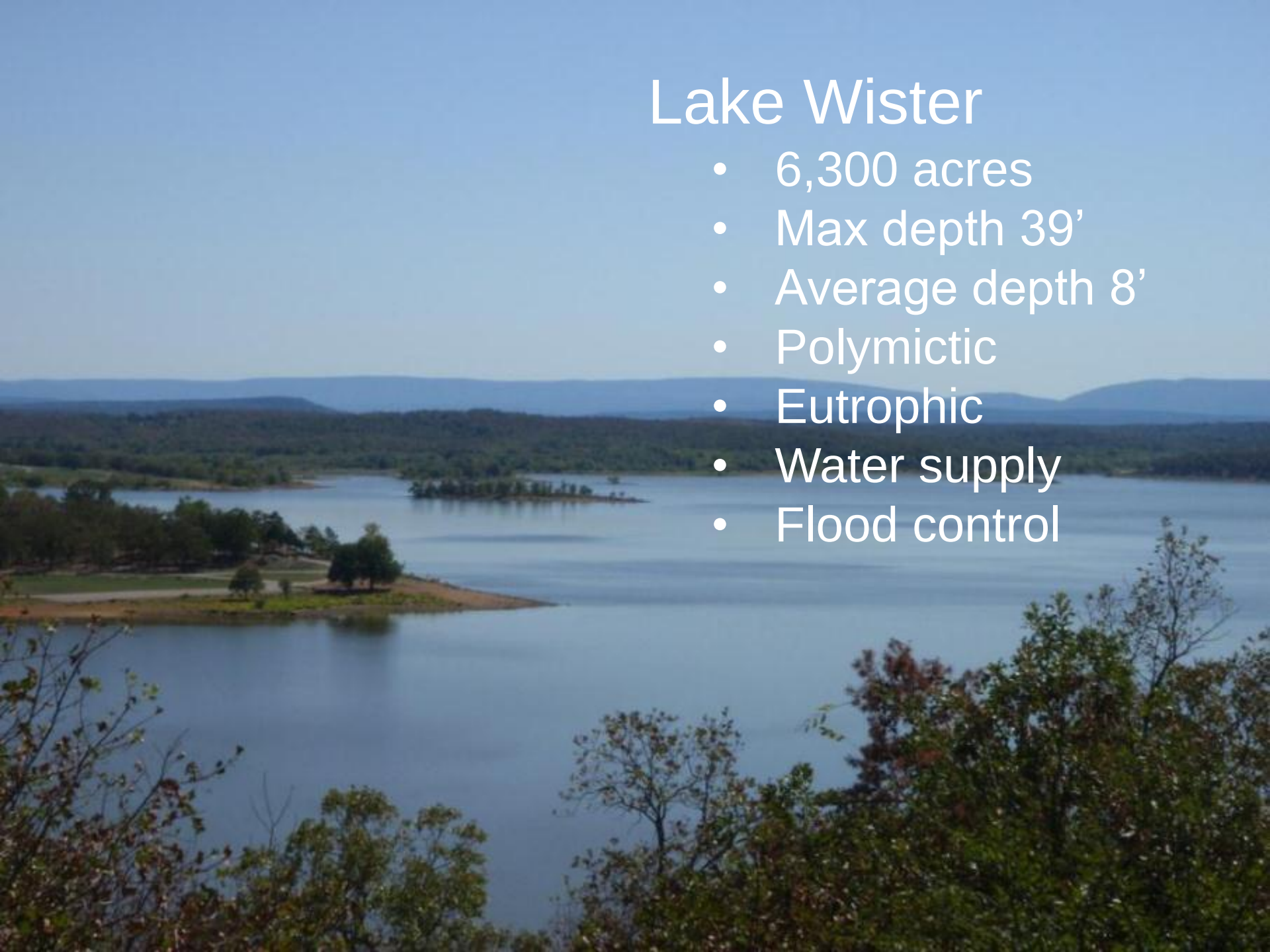
- Two main options for treatment
  - Add oxygen
  - Chemically inactivate

Why alum (aluminum sulfate)?

- $Al_2(SO4)_3$
- Used worldwide in drinking water and wastewater treatment
- Disassociates in water, hydrates, loses hydrogen ions, and form a floc of aluminum hydroxide ($Al(OH)_3$)
- Aluminum hydroxide has high coagulation & P adsorption properties
- Forms aluminum phosphate ($AlPO_4$) when it encounters phosphate
- Unlike iron-bound P, Al-P remains bound even under anoxic conditions (at normal lake pH levels),
- P removed from the lake nutrient cycle

Why sodium aluminate ($NaAlO_2$)?

- Adds alkalinity, buffers pH reduction by alum
- Same phosphate-binding function



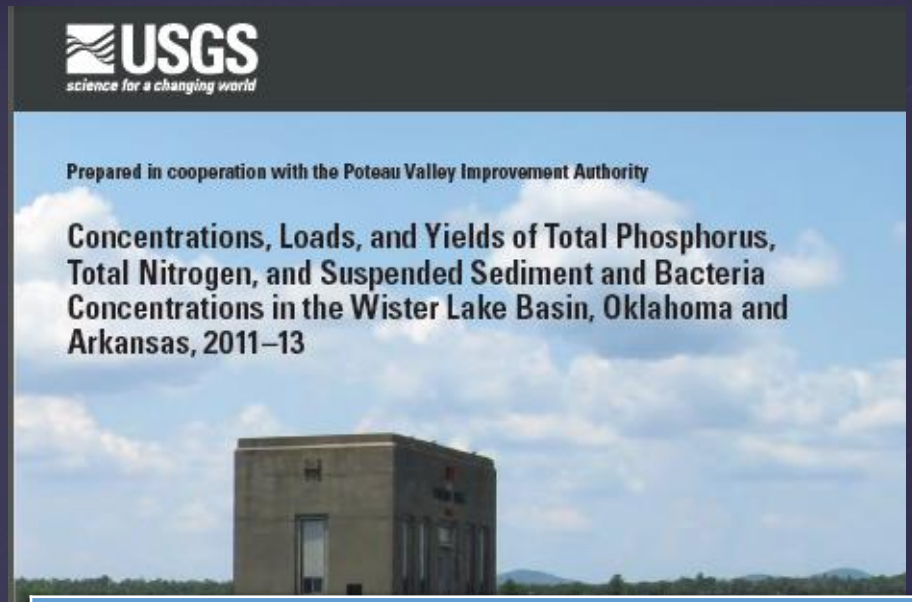
Lake Wister

- 6,300 acres
- Max depth 39’
- Average depth 8’
- Polymictic
- Eutrophic
- Water supply
- Flood control

Lake Wister Beneficial Uses

Beneficial Use	Status	Cause
Public and Private Water Supply	**Not Supporting**	Chlorophyll-a
Warm Water Aquatic Community (Fish & Wildlife Propagation)	**Not Supporting**	Turbidity pH
Aesthetic	**Not Supporting**	Total Phosphorus
Primary Body Contact Recreation	**Supporting**	
Fish Consumption	**Not Supporting**	Mercury
Agriculture	**Supporting**	

(ODEQ 2014)

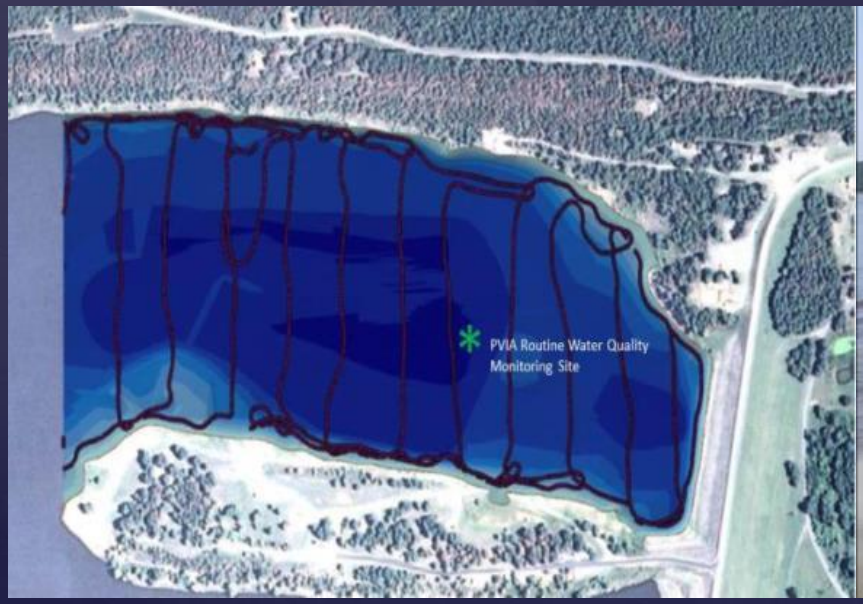


USGS sampling loads to the lake

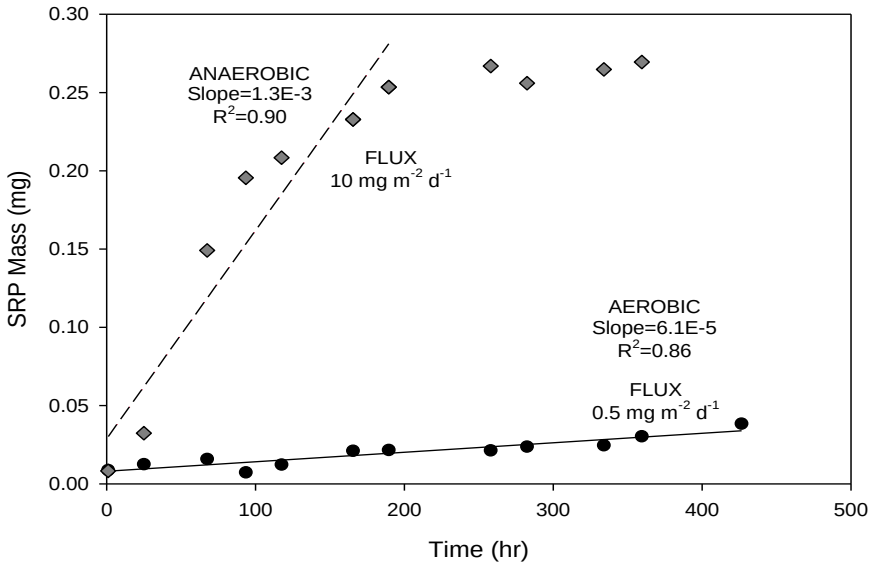
Lake Wister Nutrient & Sediment Loads 2011-2013	Average	Range
Annual phosphorus load	**412,000 lb.** (186,880 kg)	274,000 – 576,000 lb.
Annual nitrogen load	**2,090,000 lb.** (948,000 kg)	1,312,000 – 2,588.000 lb.
Annual suspended sediment load	**167,855 tons** (152,276 t)	110,909 – 234,818 T
N:P ratio 5:1		

Quarry Island Cove Nutrient Inactivation Pilot Project

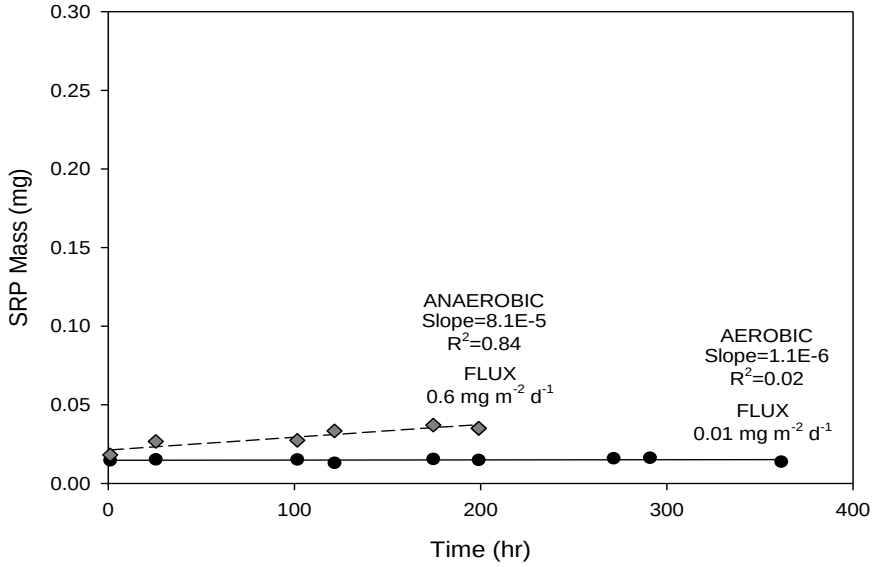
- When: August 2014
- Applied: 16,000 lbs. alum
- 8,000 lbs. sodium aluminate
- To: 100 acre Quarry Island Cove, Lake Wister



SRP Mass Accumulated Over Time
Cores Collected Prior to Cove Treatment

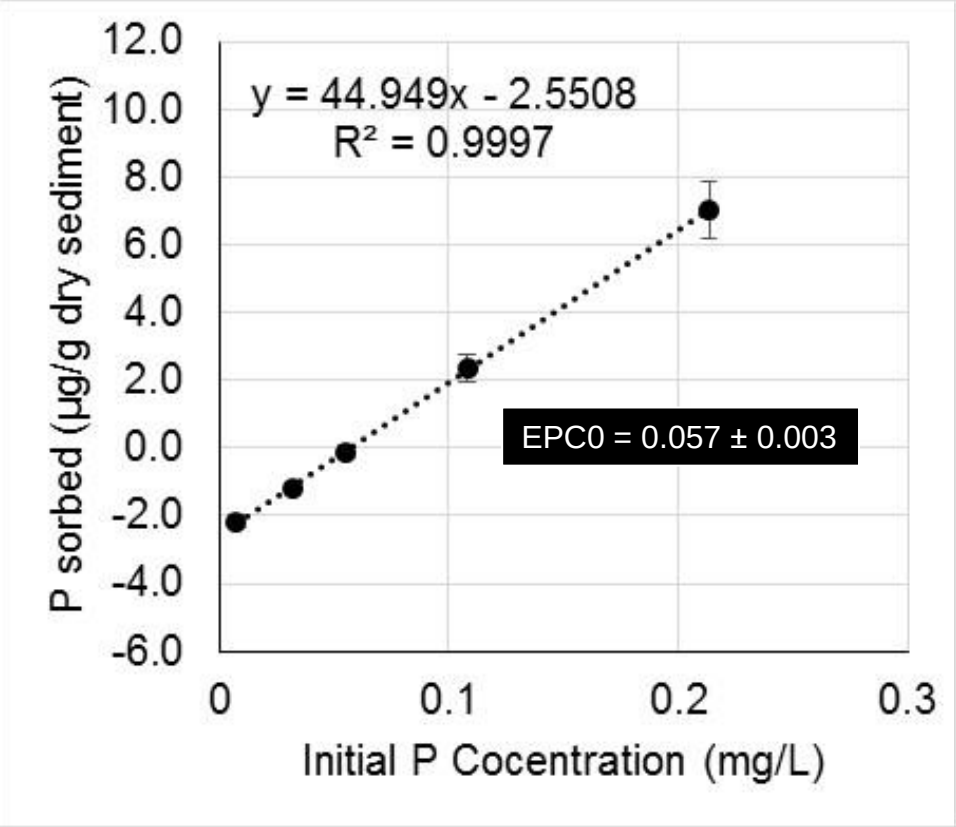


SRP Mass Accumulated Over Time
Cores Collected After Alum Additions

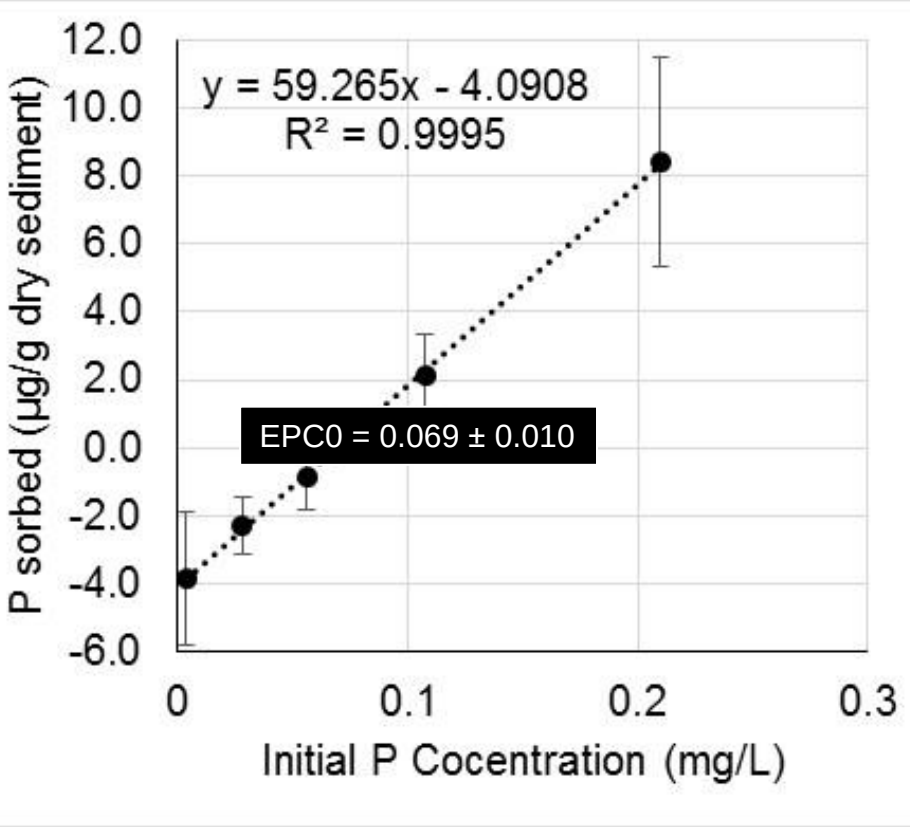


Sediment-Water Equilibrium Phosphorus Concentration (EPC0)

Before Alum



After Alum



P fractions, top 2cm, before alum

Extractant	P-fraction	Average P (mg/kg)	"Mobile" P (DI+Fe-P)	Al-P %
DI H2O	Labile	0.34		
Sodium bicarbonate (NaHCO3)	Fe-P	18.43	18.77	
Sodium hydroxide (NaOH)	Al-P	126.86		
Hydrocloric acid (HCl)	Ca-P	89.32		
Totals		234.95	8%	54%

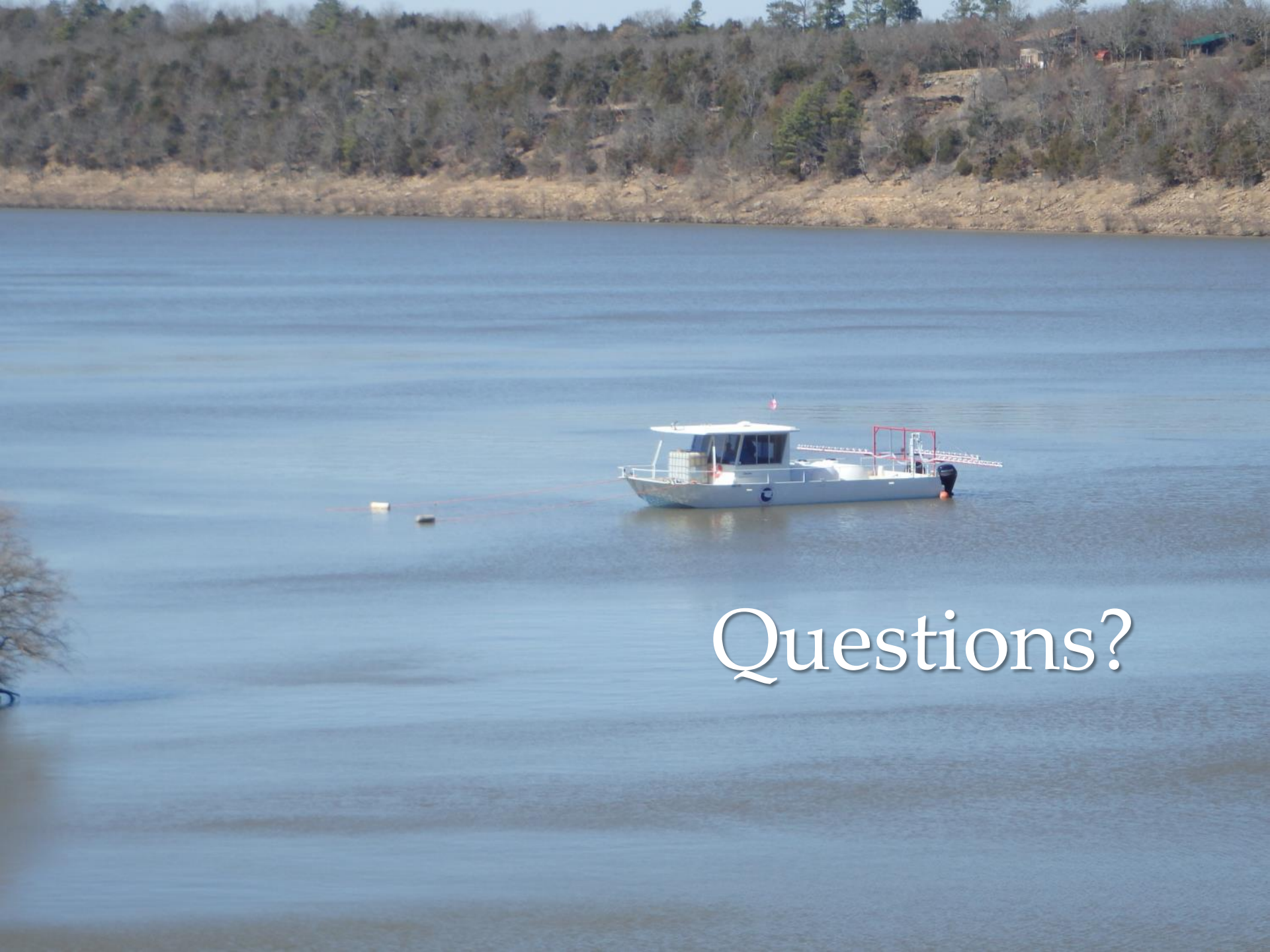
P fractions, top 2cm, before & after

Extractant	P-fraction	Average P (mg/kg)	"Mobile" P (DI+Fe-P)	Al-P %
DI H2O	Labile	(0.34) **0.14**		
Sodium bicarbonate (NaHCO3)	Fe-P	(18.43) **10.04**	(18.77) **10.18**	
Sodium hydroxide (NaOH)	Al-P	(126.86) **199.30**		
Hydrocloric acid (HCl)	Ca-P	(89.32) **95.94**		
Totals		(234.95) **305.42**	(8) **3.3%**	(54) **65%**

Mobile P in Lake Wister sediments

- In top 10cm of cove sediments

	Before alum (mg/m2)	**After alum (mg/m2)**
Total mobile P in top 10 cm	1,560 mg	766
Total Al-P in top 10 cm	10,631	12,045


Questions?